REFRACTORIES FOR GLASS PRODUCTION

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USE OF ELECTROMELTED CORUNDUM REFRACTORIES FOR FEEDER CHANNELS OF GLASS-FORMING MACHINES

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The service conditions of refractories in feeder channels is analyzed. The prospects of using electromelted corundum refractory products for feeder trays are analyzed based on their operation practice at some Russian glass factories.

Electromelted refractories are commonly used in the glass industry, mainly for the brickwork of glass-melting tanks [1]. Feeders of glass-forming machines were mainly produced from sintered high-alumina (sillimanite, mullite) refractories [2]. Lately, in view of intensified glass-melting and glass-forming processes, electromelted refractories with increased glass resistance are receiving wider acceptance in using high-efficiency glass-forming machinery.

It has been established in comparative tests that the glass resistance of melted mullite refractories is higher than that of sintered refractories of the same composition: 3 times higher for soda-lime glass, 2 times higher for borosilicate glasses, and equal to lead silicate glass.

The application of electromelted corundum and baddeleyite-corundum refractories is limited due to their insufficient thermal resistance, which prevents using them for some feeder parts, such as plungers, cylinders, shut-off plates, or burner stones. At the same time, electromelted corundum refractories are promising for feeder channel trays, providing their vitreous phase content is significantly decreased, since it may be a source of defects in products (stria, bubbles, stones) when glass melt is prepared for forming [3].

The resultant velocity of the corrosion of refractories depends on the velocity of the limiting stage in the process. When a refractory reacts with a highly viscous glass melt, such limiting stage is diffusion. The above general statements are completely true of the corrosion of refractories in feeders.

The relatively low temperature in feeders and, accordingly, the high viscosity of glass melt decrease the aggressiveness of the melt and the diffusion coefficient. At the same time, increased glass melt velocities in feeder channels facilitate the removal of products from the chemical reaction zones and shift the physicochemical equilibrium in the refractory – glass melt system; in this case the melt dynamics to a certain extent determines the rate and the depth of destruction of refractories by mechanical impact on the chemically weakened refractory.

Figure 1 shows the variation of glass melt velocities along the feeder and across it depth based on data from [4]. The velocity and temperature profiles across the channel width and depth are parabolic along the entire channel length, which is due to natural cooling of the glass melt near the refractory surface. The temperature maximum is registered at a depth of $\frac{1}{2}H$. The shapes of the velocity and temperature profiles in the cooling zone and in part of the conditioning zone are slightly different; moreover, the maximum velocity is observed on the glass melt surface, whereas the

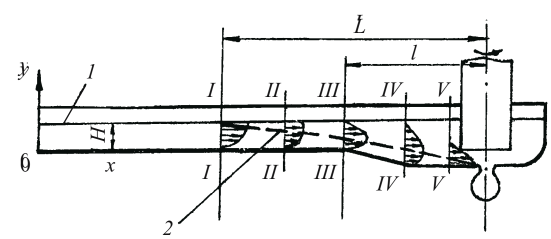

Fig. 1. Scheme of velocity variations in glass melt along the feeder: *1*) glass melt level; *2*) maximum velocity level; *L* and *l*) minimal distance from the aperture axis to the sections in which the surface glass melt velocities are, respectively, maximum and equal to zero; *I* – *I* – *V* – *V*) sections across the glass melt depth and glass melt velocity profiles for these sections.

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temperature maximum is registered at a certain depth of the flow. As the glass melt keeps flowing toward the working zone, the velocity maximum as well is shifted deeper into the flow, the velocity and temperature profiles become similar, and in dimensionless coordinates they actually coincide. The above mechanism of the hydrodynamic and thermal processes in the feeder channel causes wear in refractories determined by two factors: glass melt velocity and temperature.

Channels trays serve in less stringent conditions than other refractory parts of the feeder (plunger, cylinder, aperture, mixer). The analysis of wear in trays made of sintered mullite indicates that the most intense wear is observed at the joints between different sectors and in the walls at the glass melt level. The degree of wear of trays at different sites of the feeder is not identical. The first two sectors adjacent to the working channel are more worn along the joints, lateral walls, and bottom than other sectors. This is due to a higher glass melt temperature in this part of the feeder (1350 – 1250°C) and an increased velocity caused by the change in the flow section. In sintered high-alumina refractories we observe the formation of thin needles of alkaline β-alumina crystallized from the vitreous phase. These modifications are registered in the refractory — glass melt contact zone and penetrate 2 – 3 mm into the refractory depth. The trays located in the middle of the feeder and the tray adjacent to the feeder bowl show the minimal wear of their lateral walls and bottoms.

In view of the above, the problem of increasing the quality of refractories for feeders remains topical.

It is advisable to produce feeder trays from electromelted corundum refractories containing 95% or more Al_2O_3. Their high density and fine-grained structure determine their increased glass resistance at service temperatures. Their minimal content of the vitreous phase makes it possible to cast large-size complex-profile items without thermal cracks and raise their heat resistance to temperature differences, in particular during a starting-up campaign. This is related to the fact that the vitreous phase at high temperatures is a nonelastic element in the refractory structure and impedes the evolution of temperature stresses. The service life of refractories is significantly extended and formation of defects in preparing glass melt for forming is prevented.

When trays are made of bacor, despite the high glass resistance of the latter, corrosion, although slow, primarily occurs in the vitreous phase. It has been noted above that the increased glass melt velocities in the channel leads to accelerated removal of vitreous products of corrosion containing ZrO_2. In this process steady zirconium striae are formed and are seen on the products.

The Domodedovo Electromelted Articles Works has started mass production of electromelted corundum articles (95% Al_2O_3) for parts and channels of glass feeders. The company uses pure materials and upgraded technology ensuring the optimum composition and structure eliminating the effect of undesirable factors that could deteriorate the refractory quality. Since destruction of refractories starts from their surface, the presence of even small surface cracks significantly impairs the service reliability of refractory products. Therefore, the company technology provides for obtaining a high-quality working surface in refractories. Such surface should persist in the future. A glass factory should take care to avoid any mechanical damages or abrupt thermal shocks in putting refractory products into service, especially during the heating-up campaign.

Fig. 2. Stand assembly of a feeder channel using upgraded trays from electromelted corundum refractory.

The company produces corundum feeder trays with a smooth transition from the bottom to the wall (Fig. 2). This prevents the formation of stagnating glass melt sites in these parts and to a large extent prevents the formation of defects in the form of stria, stone, etc.

The performed tests and successful service at different glass works (Solnechnogorskii, Malovisherskii, Astrakhan'-steklo, Fakel, Berizichskii, Kamyshinskii, Krasnoe Ekho, Klinsteklotara, Krasnyi Oktyabr', Stupinskii Glass Plastic Works, etc.) confirm the increased resistance of electromelted corundum products compared to refractory items made of sintered mullite. With appropriate maintenance the service life of electromelted corundum feeder trays may reach 10 years or more.

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